

STRUTJET MATURES TO SUPPORT PROPULSION NEEDS IN THE 2000+ WORLD

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Abstract

The Strutjet, Aerojet's Rocket Based Combined Cycle (RBCC) concept, was discussed in a previous ISABE paper as an enabling propulsion concept for single stage to orbit applications. This paper describes the technical progress of the Strutjet since 1996 together with a rationale why RBCC engines in general, and the Strutjet in particular, lend themselves uniquely to systems having the ability to expand current space and also open new global "rapid delivery" markets. In particular, the paper substantiates the claims why for certain missions RBCC powered vehicles can be operated at higher margins than all rocket systems, and why within the family of conceivable RBCC systems the Strutjet excels due to its unique architecture and design features.

A special emphasis is given to the selection of the engine's ram/scram mode design point because only that mode can add significantly to the mission effective Isp. The thrust produced by an airbreathing engine is directly related to the mass of air processed. This air is captured by the inlet and compressed to raise the pressure for combustion and subsequent expansion. The net accelerating force is the difference between the gross thrust and total vehicle drag (including the spill drag). This total drag is highest at low speeds when the gross thrust is lowest. When the net accelerating force is low, most of the fuel burned is wasted overcoming the vehicle drag. Higher thrust is necessary to perform the mission. One method is to leave the rockets on longer but this results in much higher propellant consumption. A better method is to increase the airbreathing thrust. It can be shown that in the ram/scram mode the thrust is proportional to the

product $F_{ct}(M) * \eta_{cap}$, in which $F_{ct}(M)$ is a function decreasing with increasing Mach number, and η_{cap} is the inlet capture efficiency. Although $F_{ct}(M)$ is to some degree dependent on the efficiency of the overall ram/scram engine design and its integration into the vehicle, the strongest influence on thrust can be materialized through appropriate manipulation of η_{cap} . Figure 1 shows the net thrust resulting from various design points. The engine with the Mach 6 design point produces more than twice the thrust of the Mach 12 design at Mach 6, in the middle of the airbreathing acceleration. The thrust does not cross over until after Mach 11, and then it is only slightly better than at the Mach 6 design. The vehicle benefits of selecting a lower Mach number design point is illustrated in Figure 2. As shown, both dry weight and takeoff gross weight experience a significant reduction.

As part of NASA's Advanced Reusable Technology (ART) program, Strutjet technology has been extensively evaluated over its entire operating range. Its design maturity has been continuously improved and desired features, like simple variable geometry and high performance flowpath, have been verified. The paper summarizes the results of these tests and discusses plans how this system could be flight tested once an RBCC flight test bed is available. In addition, data is now available which allows the designer, who is challenged to maximize system operability and economic feasibility, to choose between hydrogen or hydrocarbon fuels for a variety of application. The ability exists now to apply this propulsion system to various vehicles with a multitude of missions.

Classic Md12 SOL Forebody @ M = 6

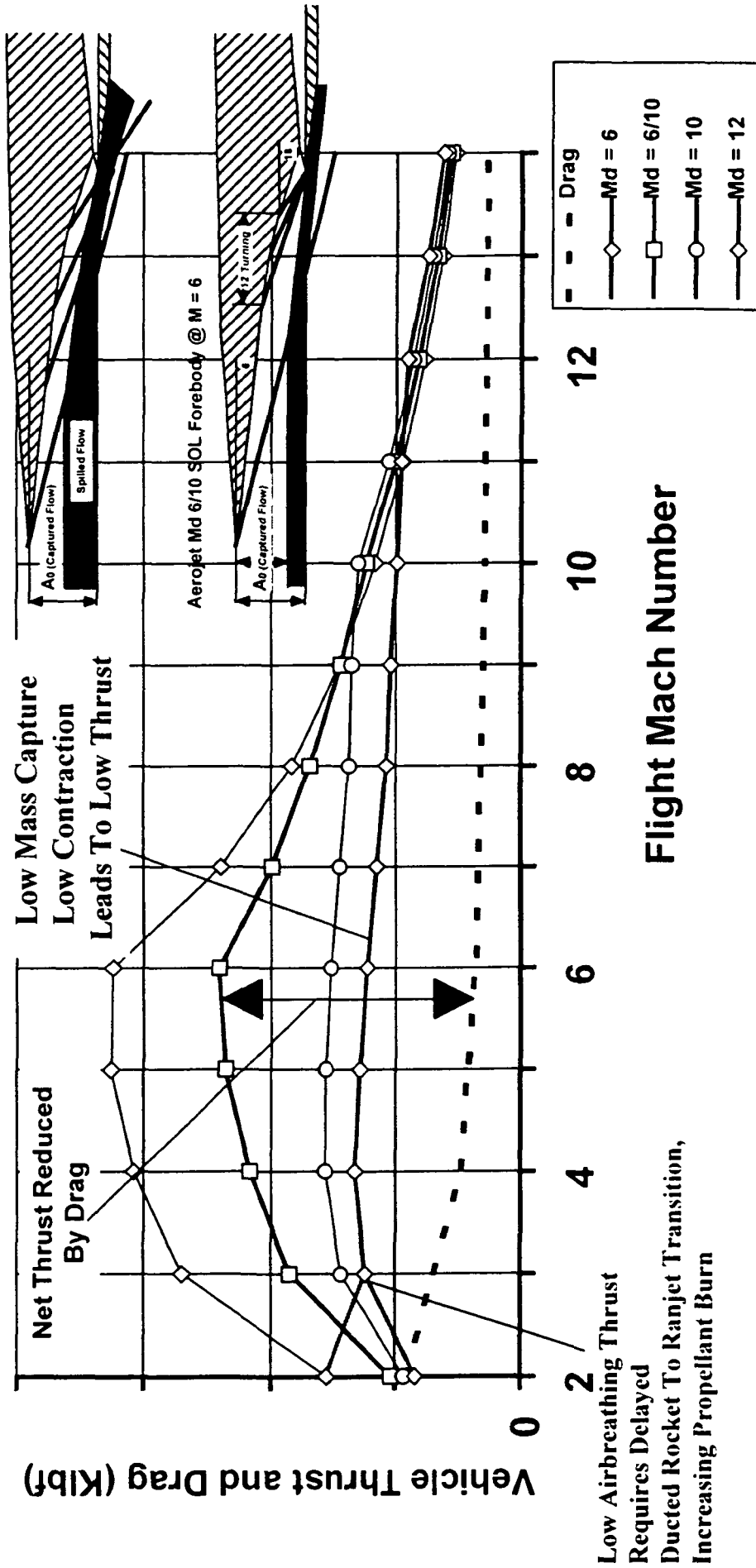


Figure 1: High Mach Number Inlet Designs Result In More Performance Losses At Low Speed Than Performance Gains At High Speed

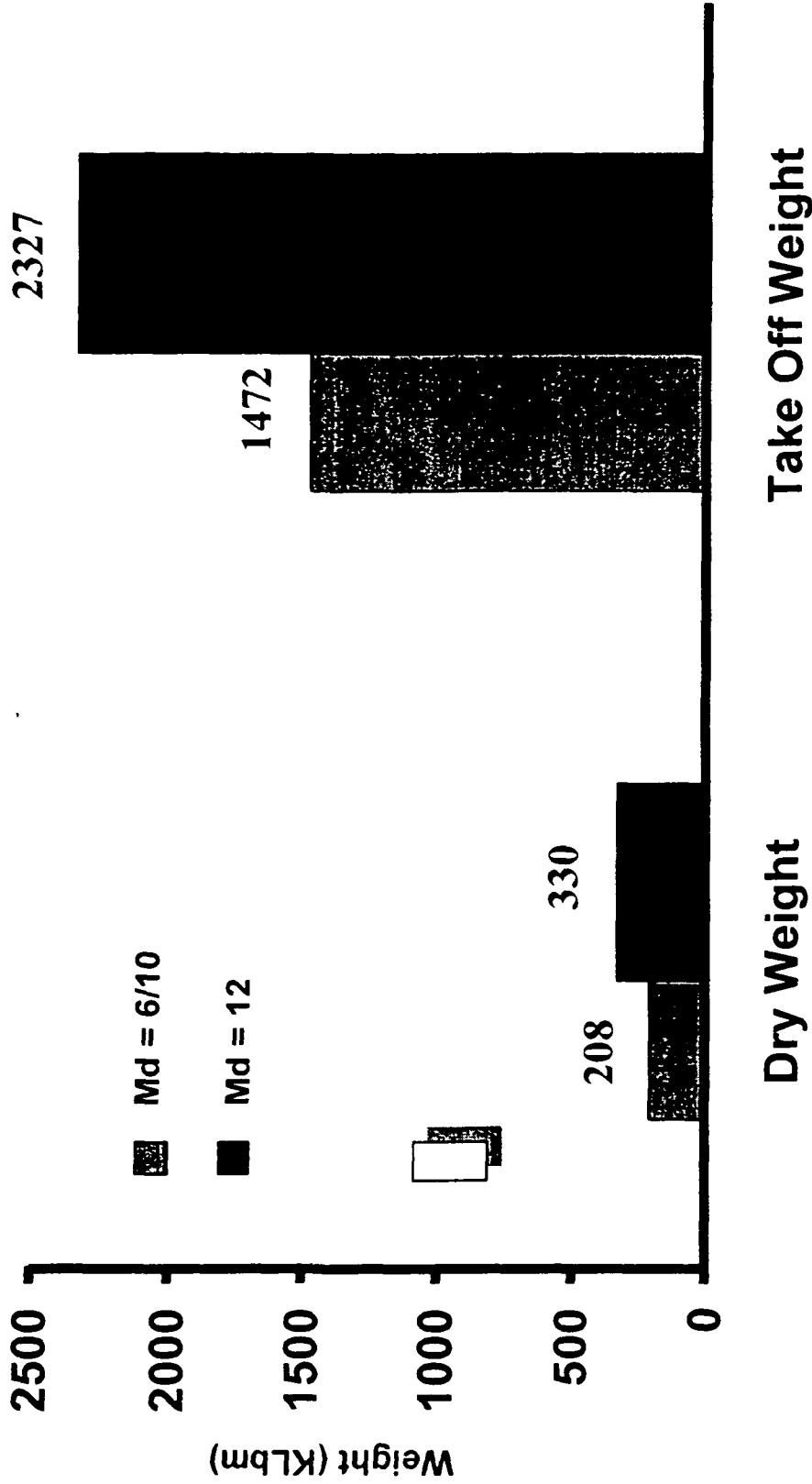


Figure 2: Most of 37% Reduction In Both Dry Weight & Take Off Weight Can Be Attributed To Lower Inlet Design Point Selection